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Constructability improvement : making effective use of construction lessons learned.

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CONSTRUCTABILITY IMPROVEMENT: MAKING EFFECTIVE USE OF CONSTRUCTION LESSONS LEARNED

by

Robert Henry Morro

Thesis submitted to the Faculty of the Graduate School
of The University of Maryland in partial fulfillment
of the requirements for the degree of
Master of Science
1991

Advisory Committee:

Assistant Professor Nabil Kartam, Chairman/Advisor
Professor Donald Vannoy
Professor William Maloney

ABSTRACT

Title of Thesis: Constructability Improvement:
Making Effective Use of Construction
Lessons Learned

Robert Henry Morro, Master of Science, 1991

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Expert knowledge and lessons-learned in the construction phase of a project are not being effectively fed back to the design and construction phases of subsequent projects. The advancement of construction since ancient times has been predicated on the communication of lessons-learned. Anecdotal story telling has evolved into case studies and formal systems for the classification and dissemination of lessons-learned. While past efforts have focused on the design phase, opportunities for collection and dissemination exist in all phases of the facility life-cycle. Constructability, the early integration of construction knowledge into all phases of a project, can be improved by effectively utilizing lessons-learned. Traditional methods of collecting and disseminating construction lessons-learned have enjoyed limited success due to the unmanageable format, the lack of a meaningful classification system, and difficulty integrating the new system into existing operations and procedures. Current

hardware and software environments provide powerful tools for constructors to document and communicate lessons from the field more effectively. This thesis analyzes existing lessons-learned systems, identifies the challenges to effective feedback systems, and proposes a model of a knowledge based information system for construction. Potential benefits of an effective knowledge based feedback system include more efficient construction, higher quality projects, and safe, on schedule completion, for the least cost.

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DEDICATION

To my bella moglie, Anita.

ACKNOWLEDGEMENT

Prof. Nabil Kartam provided the invaluable support and encouragement I needed to select and pursue this topic. His expert knowledge and expert systems sparked my interest in the subject. Prof's. Donald Vannoy and William Maloney also supported the effort.

We would like to thank the George Hyman Construction Co. for their generous financial support. Mr. Alan Petrasek and the Research and Development Committee are forward thinking individuals, genuinely interested in improving the quality, efficiency and competitiveness of the construction industry. Special thanks to Mr. Ray Register, Mr. Steve Smithgall, Ms. Lisa Enlowe and the other Hyman experts who patiently shared their rich construction knowledge with me.

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CHAPTER I - INTRODUCTION

It has been said that the only thing we learn from our mistakes, is that we don't learn from our mistakes.

The inaugural article of the ASCE Journal of Performance of Constructed Facilities [Carper, 1987], highlights the importance of learning from the past:

> The concept of learning from failures is fundamental to the practice of engineering. . . In the past, builders based their designs on observations of performance of earlier construction. Failures usually led to a better understanding of physical behavior and to a corresponding improvement in design. Communication among designers about lessons learned from failure has always been an important component in the advancement of the engineering professions.

During the construction of any facility, knowledge is gained and lessons are learned. Over time, those involved in construction processes have the opportunity to accumulate a plethora of knowledge, some of which was learned at great human or financial cost. Benefits in cost, quality, time and safety could be realized on future projects, if this wealth of constructability knowledge could be harnessed effectively.

The Constructability Task Force of the Construction Industry Institute (CII) sponsored a series of studies which advocate construction expert input to the conceptual planning [Tatum 1987], and engineering and procurement phases [O'Conner et al. 1987], as well as field operations [O'Conner et al. 1988], as the key to more efficient construction and

achievement of overall project objectives. While admitting that cost savings are difficult to quantify, the Business Roundtable estimates that constructability improvements saved 20 times the cost of the program ["More Construction" 1983]. Tatum expounds on the difficulties of quantification and enumerates some intangible benefits: team building, improved coordination, greater construction planning, and adoption of a project viewpoint by all team members [Tatum 1987].

Generally, lessons-learned in the construction phase of a project are not effectively being fed back to the design and construction phases of other projects. O'Conner and Davis conclude that **constructors** need to improve documentation of lessons-learned related to field constructability and to communicate them more effectively [O'Conner et al. 1988]. CII advocates a corporate lessons-learned database as a key element in any constructability program ["Guidelines" 1987]. Traditional methods of gathering and using lessons-learned have enjoyed limited success due to the unmanageable format, the lack of a meaningful classification system and the difficulty of integrating new systems into existing operations and procedures.

Knowledge based expert systems (KBES) provide a means of representing and reasoning with heuristics, or rules of thumb, employed by experts. Linking a database, a KBES, and hypertext capability facilitates rapid retrieval of information as well as the ability to reason within the knowledge base using if-

then rules. If the experience and lessons-learned at the construction site could be captured and incorporated in a dynamic, interactive, knowledge based information system and utilized in the design and construction of future facilities, great benefits could be realized. These benefits include more efficient construction and improved cost, quality and safety.

This research focuses on CONSTRUCTION. The goal is to develop a model of a practical tool with which to compile and benefit from the accumulated corporate knowledge of a medium or large size construction firm. The unit of knowledge is termed a lesson learned, and covers a broad spectrum of information from horse sense to technically sophisticated construction methods. We begin by exploring feedback opportunities in the project life-cycle, and analyzing related efforts to classify and utilize lessons-learned in engineering and construction. Challenges to effective feedback systems are then identified. Based on the analysis of existing systems, and consultation with construction industry experts, we develop a classification system for construction knowledge. Finally, we examine knowledge acquisition, knowledge engineering and implementation issues critical to the success of such a system.

CHAPTER II

FEEDBACK IN PROJECT LIFE-CYCLES

Lessons-learned from constructed facilities may have their genesis in any phase of a project's life-cycle. Similarly, these lessons may be applicable in one or more phases of the project life-cycle. The various sources and uses of engineering/construction knowledge are depicted in Figure 1. Three feedback loops from the construction project life-cycle will be examined in detail.

Value Engineering

Some feedback loops, for example, Value Engineering (VE), have become formalized in the construction industry. Value Engineering is traditionally viewed as an intentional reexamination of existing designs or hardware by the construction contractor, usually on an incentive basis [Kavanagh 1978]. Value Engineering, like constructability, focuses on life-cycle cost. VE is a feedback loop generally confined to the design phase.

Obviously, the earlier a value engineering study is conducted, the greater the potential to influence that project. VE studies that occur late in the design phase, or after design is complete, are limited. For example, the suggestion of an alternate structural system after the design

is complete, would most likely be rejected because it would entail substantial redesign and considerable loss of time. This illustrates the importance of feedback occurring, or lessons being available, as early in the process as possible. The concept of greater potential benefit from early feedback is a key element of constructability, and will be explored in the following section.

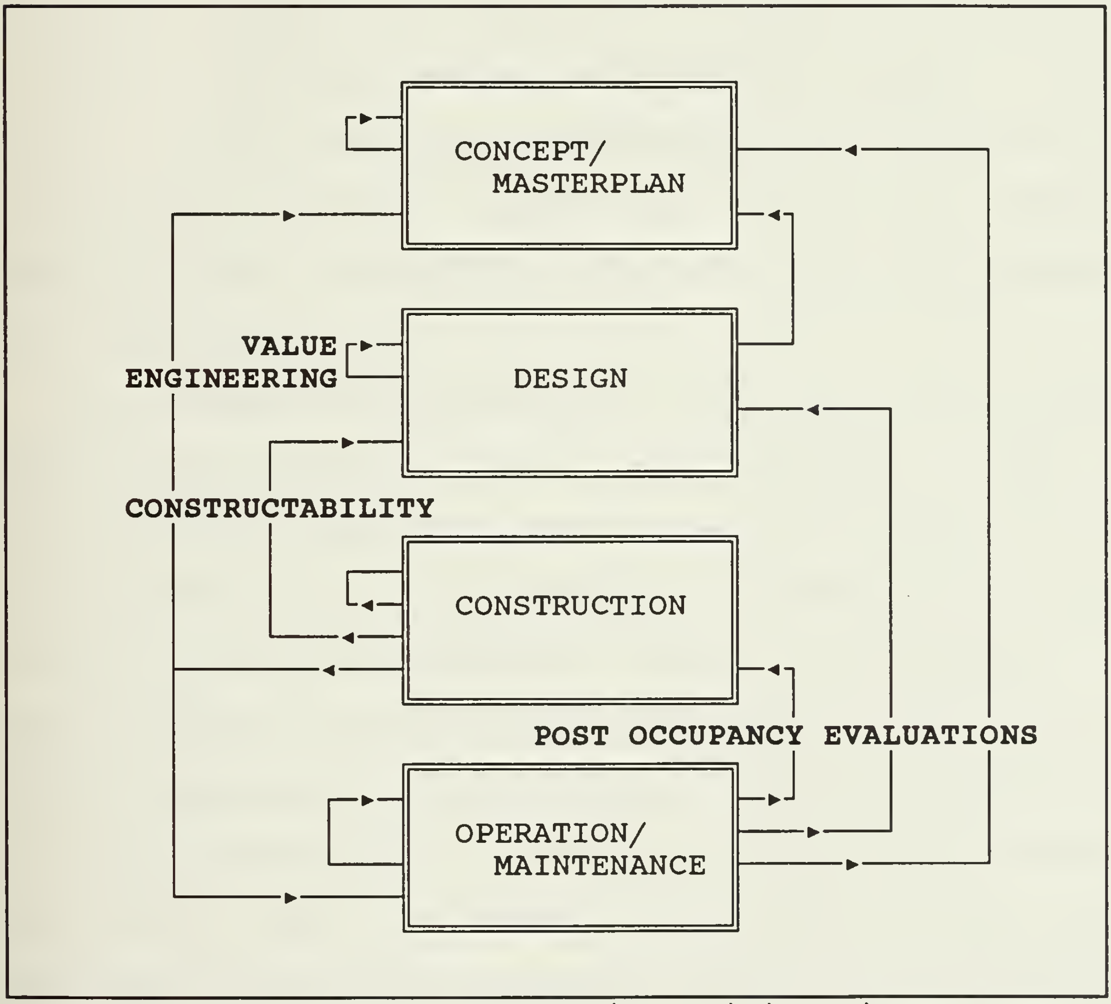

FIGURE 1. Feedback Channels in Facility Life-Cycles

Constructability

Constructability provides yet another feedback mechanism in the life-cycle of a facility. But what exactly is constructability?

The Construction Industry Institute shuns the notion that constructability is merely a review of a completed design by construction experts. Rather, it espouses the basic constructability premise that integration of construction knowledge and expertise into **early** planning, design, and in fact, all phases of a project is beneficial. It also recognizes the need to bridge the traditional gap between engineering and construction **early** in the project if full benefit is to be achieved ["Guidelines" 1987]. CII has also commissioned various studies on ways to improve constructability [Tatum 1987, O'Conner et al. 1987, O'Conner et al. 1988].

The Construction Management Committee of the ASCE Construction Division echoes the sentiment that "a constructability program is not just reviewing the plans and specifications after the design is finished and making comments" ["Constructability" 1991]. It defines a constructability program as "the application of a disciplined, systematic optimization of the construction-related aspects of a project during the planning, design, procurement, construction, test, and start-up phases by knowledgeable, experienced, construction personnel who are part of a project

team" ["Constructability" 1991]. CII further recognizes that constructability is not a natural process, rather it demands a conscious, continued effort.

Constructability encompasses all feedback loops that emanate from the construction phase. The input of construction expertise is desirable in all phases of the facility life-cycle, and it is depicted accordingly in Figure 1. The focus of this research is the feedback loop that begins and ends in the construction phase.

Post Occupancy Evaluations

Post Occupancy Evaluations (POEs) represent another formal feedback loop in engineering/construction. The evaluations occur during the operational and maintenance phase of the life-cycle, but can be applied in virtually any phase. Many owners of a large number of facilities employ POEs to assess the effectiveness of their design and construction programs. The Army, Navy and the General Services Administration all have active POE systems [Plockmeyer, 1988].

Comments made in a POE often pertain to the maintainability of the facility: provide adequate space in mechanical rooms to pull shafts from air handling units. Other comments relate to the durability and functionality of the constructed facility: quartz wall coverings are tough enough to withstand typical (ab)use in barracks settings, but light colors should be avoided since they show scuff marks; metal

clad buildings in the vicinity of airport ground control radar can adversely effect operations, reflective/adsorptive properties should be considered carefully.

Lessons gleaned from the operation and maintenance of completed facilities may be too late to benefit that facility but are potentially useful on subsequent facilities. By definition, POE's occur after completion of a facility or structure. Benefits accrue when these lessons are utilized early in the planning, design and construction of subsequent facilities and structures.

Following the axioms postulated by the Construction Management Committee of the ASCE and the CII, this research proposes a practical method to realize some of the goals of a constructability program, focusing on lessons-learned in the **construction** phase. This construction knowledge has the potential to be utilized in all phases of the project life-cycle. We make use of highly knowledgeable, significantly experienced, construction experts to examine the issue of classifying construction knowledge. Chapter three examines various efforts to collect and disseminate knowledge gained in the architecture/engineering/construction world.

CHAPTER III - BACKGROUND AND RELATED WORK

To investigate the state of the art in engineering-construction feedback systems, letters were sent, and follow-up phone calls were made to various universities, colleges, organizations (CII, ASCE, AEPIC) and construction firms who have historically conducted research or performed work in this area. The response rate of over 60 percent was encouraging. Finally, personal interviews were conducted.

Many professional organizations have initiated efforts to collect and disseminate failure and performance information in specific disciplines and specialized fields: soil and foundation engineers (ASFE), fire protection engineers (NFPA), National Bureau of Standards (NBS), the Committee on Large Dams (COLD) of the ASCE, and the National Transportation Safety Board (NTSB) for the Federal Aviation Administration (FAA).

On an inter-disciplinary level, the Architecture and Engineering Performance Information Center (AEPIC) at the University of Maryland [Vannoy, 19837], the <u>Journal of Performance of Constructed Facilities</u> of ASCE [Carper, 1987], and the Center for Excellence in Construction Safety at West Virginia University [Eck, 1987] have attempted to integrate lessons-learned from the performance of constructed facilities into industry practice. We are concerned with performance

information spanning all trades and disciplines in an engineering/construction context.

While many organizations have formal or informal methods of obtaining and utilizing feedback in the DESIGN arena, relatively few attempts have been made to collect, classify, or disseminate lessons-learned from the CONSTRUCTION phase of the project life-cycle. Although the following systems are not construction oriented, the various approaches and classification systems developed by these architecture and engineering professionals are analyzed to gain insight into the essential elements of a successful system. A description and critique of various existing systems is presented below.

Much of the work in this field has been done by forensic engineers. Before delving into these systems, it is imperative to clarify the vocabulary that will be used. In the context of forensic engineering, failure is defined as "an unacceptable difference between expected and observed performance" [Carper 1989]. These failures range in scope from mundane roof leaks to notorious disasters like the failure of the Teton Dam (1976) and the Kansas City Hyatt Regency (1981) walkway collapse.

> Minor failures are much more frequent and their cumulative economic effect is more significant. . . It has been suggested that the use of words such as "incident" or "accident" rather than "failure" might encourage discussion of these less spectacular performance problems. The dam and nuclear industries have found it necessary to develop such a vocabulary to deal with events which are less than catastrophic [Carper, 1987].

Architecture & Engineering Performance Information Center

Mr. Neal FitzSimons began the seminal work in forensic engineering performance classification systems in 1964. He subsequently published "Making Failures Pay" [FitzSimons, 1981] and, along with Prof. Donald Vannoy, initiated what was to become the Architecture and Engineering Performance Information Center (AEPIC) at the University of Maryland. The mission of AEPIC is summarized in Architecture and Engineering Performance Notes:

> The initial objective of AEPIC . . . is the improved design, construction and performance of buildings, civil structures and other constructed facilities. That objective is based on the premise that collection, analysis and dissemination of information on performance . . . will assist in the improvement of the built environment . . . [AEPIC 1, 1988].

In 1986 AEPIC began to collect information from two major sources to incorporate into the first computerized depository for failure data of this type. The first source was case files from one of the primary companies providing liability insurance for architects and engineers. The second source was Federal and State Appellate Court case summaries involving building and civil structure failures [AEPIC 1, 1988]. The AEPIC system is one of epic proportions with over 4,000 coded cases. This scheme has 67 different data fields [Appendix A] covering numerous of topics, including the parties involved, ordinary project information, extraordinary project details such as the size of the component, property damage, bodily injury/death, and the location, cost, catalyst and cause of he

incident.

The AEPIC Dictionary of Quick Codes is included as Appendix A. As the data fields illustrate, this system catalogs performance incidents from the perspective of a forensic engineer. The original vision was for an all encompassing database of performance information, but the current system is constrained by it's sources of information. Given the sensitive nature of information dealing with actual or alleged failures and litigation, it is very difficult to acquire factual data. Claims cases, purged of incriminating information to protect privacy, are perhaps the only realistic source of large scale data of this sort.

Some of the AEPIC data fields are not applicable to a feedback system customized for construction, but two are noteworthy. The PROJECT USE category defines the purpose of the facility and is split into two broad categories: Structure/Civil and Buildings. A comprehensive list is provided for each. AEPIC utilizes the broad categories of construction outlined in the CSI Divisions but further refines them by adding a COMPONENT/ELEMENT category to cover such things as walls, floors and specific systems. Although this particular classification system is failure oriented, it represents considerable thought in its comprehensive structure.

The volume of encoded information facilitates the analysis of trends over time. The results have been published

in a series of newsletters with various graphical summaries. Performance failure trends were identified and analyzed. For example, siting and excavation problems make up 18 percent of all performance incidents in terms of property damage and management problems. Roofing problems account for 10 percent of the reported failures. Of the roofing failures, 61 percent involve water penetration while 35 percent involve structural failure [AEPIC 4 & 5, 1988].

This classification system is by far the most elaborate developed to date. At its inception, there was tremendous enthusiasm, excitement and support in the trade journals, but in recent years the AEPIC system has not enjoyed widespread use. The objectives are clear and worthwhile, but the system seems to lack focus, and integration into actual practice has not occurred.

The AEPIC target audience is vast and includes architects, engineers, contractors, developers, manufacturers, lawyers, building owners and users, federal and state agencies, insurance underwriters, university and private research organizations and others [Loss 1987]. There are a myriad of potential uses, but no specific customer. The sources and volume of encoded information make the database effective for research and analysis of trends, but perhaps too broad and unfocused for individual clients.

The AEPIC system was initiated almost ten years ago, employing basic database technology. Recent advances in

knowledge based expert systems, hypermedia techniques, and interactive graphical user interfaces (windows) can now be incorporated into feedback systems such as AEPIC to encourage direct user interaction.

American Society of Civil Engineers

Various committees of the American Society of Civil Engineers have collected and categorized information regarding failures, accidents and performance of dams and hydraulic structures for many years ["Lessons," 1975; "Lessons," 1986]. Each publication contains case studies collected through questionnaires and generally includes a narrative description of the structure and the incident. Although substantial work has gone into collecting and disseminating performance information related to hydraulic structures, no attempt at a comprehensive classification system has been made.

The Journal of Performance of Constructed Facilities, is published by the ASCE and jointly sponsored by the National Society of Professional Engineers (NSPE/PEPP) and AEPIC. As the first jointly sponsored journal, its objective is the development of professional practices to improve quality and promote public confidence in the engineering design professions. Published since 1987, this journal "seeks to coordinate and expand failure information dissemination strategies" [Carper, 1987].

The journal has featured case studies of performance

failures, as well as a spectrum of professional views on alternate dispute resolution methods. The recent explosion of litigation has prompted engineering professionals to not only consider methods to reduce failures, but to explore creative ways to resolve the disputes that consequently erupt.

Currently, there is no industry standard for classifying performance information. David Nicastro, and the Committee on Dissemination of Failure Information of the ASCE Technical Council on Forensic Engineering is currently studying the matter and hopes to adopt a taxonomy for classifying performance data. He is implementing an expert-system that will incorporate the work done by AEPIC and others, but will go beyond all of the resources of which we are currently aware in systematically classifying failures. In a recent letter, David Nicastro notes:

> A common problem with previous classification systems is that they generally start out by pigeon-holing the failure, and then describing its characteristics. For development of a computerized expert-system, the opposite approach is required. Our system is based on a parameter tree model, whereby the characteristics of a failure are checked against a list of parameters, and the sum of the characteristics defines the failure.

The committee hopes to adopt a uniform system for classifying failures, similar to the well known biology taxonomy (kingdom, phylum, species). It believes that the adoption of a common structure by ASCE would be a major step toward industry standardization and would be an enormous benefit for communication and research.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers, Construction Engineering Research Laboratory (CERL) has developed two systems to improve constructability through design review. The first, Automated Review Management System (ARMS), was developed to help managers track constructability and design reviews of construction projects with the major participants being geographically dispersed. ARMS manages review deadlines at all user levels, provides database management for comment manipulation and analysis, provides for electronic forwarding of comments, and permits on-line or off-line batch comment generation and uploading using standard word processors [Kirby, 1991]. This system is designed as a management tool, and aids in the constructability process, but does not actually contain performance information.

The follow-on system, currently under development, is called BCO Advisor: Expert System for Biddability, Constructability and Operability Review. It is a personal computer based hypertext system designed to help U. S. Army Corps of Engineers personnel perform constructability reviews on construction design documents. The prototype system employs the KnowledgePro expert system shell. It uses a menu-driven knowledge base program with hypertext as the shell for interactive checklists. The user interactively compiles a tailored checklist based on the design stage (35% design, or

95% design) and discipline or CSI division of interest, for later printing. This customized checklist is then used to review the design of a particular project. The prototype contains over 2500 individual comments (check-list items) from various sources, over half of which deal with "routine design construction evaluation" [Kirby, 1991].

The BCO Advisor has a different goal than our construction lessons-learned system. It is design oriented and produces a checklist, while our system endeavors to harness construction expert knowledge. It utilizes a review comment (coordinate roof openings on architectural, structural and mechanical plans) rather than a performance lesson (ensure curing compound used on roof slab is compatible with proposed roofing system) as the basic unit of knowledge.

BCO Advisor is, however, instructive from two points of view. First, it is technically sophisticated and effectively utilizes a KBES with hypertext to rapidly retrieve appropriate comments in an extremely user friendly environment. Second, it is well integrated into the existing operations of the Army Corps of Engineers. Previously, engineers performing design reviews had to root around for an appropriate checklist, or rely on their memory for the myriad details to be reviewed. Upon completion, the comments had to be packaged and mailed to the responsible agency. With the BCO Advisor, a checklist can be interactively compiled, annotated with comments as the review progresses and mailed electronically. It fits nicely

into the traditional method of accomplishing the task, yet improves productivity.

Naval Facilities Engineering Command

The Design Division of the Naval Facilities Engineering Command has initiated numerous attempts to gather and classify lessons-learned in the design and engineering of facilities for the Navy. Dr. Michael Yachnis, former Chief Engineer, assembled and published a book in 1985 with over one hundred lessons titled "Lessons Learned from the Design & Engineering of Naval Facilities" ["Lessons," 1985]. It is generally organized by discipline (structural, architectural, mechanical), but includes some problematic areas of concern to the Navy (corrosion, cranes, welding & non-destructive testing, and physical security). Each lesson includes the problem, symptoms, collection of facts, and solution as well as sketches where applicable.

Numerous follow-up efforts by the Navy's Design Division have resulted in a number of local systems, including: "Design and Maintenance Observation Feedback System." This system has two components. The first is a database of design criteria feedback from all possible sources, accessible by discipline or by a five digit category code (cat-code). Cat-codes are used by the military to represent very specific facilities (aircraft parking apron, brig, B-52 flight simulator, transmitter building, guided missile spares storage). The

second component contains maintenance feedback, organized by cat-code. It is derived from various sources, though predominantly post occupancy evaluations.

This system and others were considered working prototypes but suffered several short-comings. Their capacity was limited by the software, but was adequate for the start-up phase. A formal method of collecting and inputting the observations was missing. Data collection was sporadic and the quality of the observations was inconsistent. The system was physically located at headquarters, but most of the raw data occurred at the field level. The system was a stand alone; it was not integrated with existing software or procedures. Updating the system required extra effort from a project engineer or a dedicated data entry person.

Drawing on the lessons of their previous attempts, Mr. Tom Hurley, at the Design Division of the Naval Facilities Engineering Command, has developed an exemplary value engineering database. This system has gained widespread use in the Navy in the last year. It is written in "C", uses Clipper database software, and stores information on compact disks. The results of value engineering studies conducted at various Department of Defense field activities around the world are submitted on floppy discs and batch loaded into the Navy's corporate database. This system scores high marks for integration into the existing method of doing business. The database grows from a regular diet of "accepted" value

engineering comments, currently over 16,000. Like the Navy's Guide Specifications, it is distributed on read-only compact disks.

Target users are anyone in the Department of Defense that designs new facilities. Current Navy policy requires all such designers to conduct "0%" value engineering review. Before commencing design, they simply review the accumulated value engineering suggestions by cat-code, for the type of facility under consideration. Project specifications are developed by computerized cutting and pasting and both guide specifications and value engineering lessons are located on the same menu.

This value engineering database overcame the integration problems and was developed with an appreciation of the big picture, or the overall mission of the organization. It's weakness lie's in the collection and verification of data. Many valid value engineering comments are not "accepted" for a particular project because of the advanced stage of design. Acceptance would essentially require redesigning the facility. These "rejected" comments are not appended to the database, although they may be beneficial. Other accepted comments may be appropriate for a facility in one location, but inappropriate in a different location. The system has no way of sorting or classifying except by cat-code and discipline. It relies on the user's expertise to judge the appropriateness of each comment.

International Work

A number of international organizations exist that are pursuing work in failure information dissemination. A review of international publications revealed extensive case studies and compilation of failure data, but did not reveal any information about specific classification systems. Major international organizations include: the Building Research Establishment (BRE) of the United Kingdom; National Research Council of Canada; BYGGDOK, a Swedish organization; the National Timber Research Institute of South Africa; and SOCOTEC, a French organization [Carper, 1987]. Other work was done by Raikar in India [Raikar, 1987] and by Matousek in Switzerland [FitzSimons, 1978].

CHAPTER IV - CHALLENGES OF EFFECTIVE FEEDBACK SYSTEMS

The problems discussed in the preceding chapter illustrate a common theme among various attempts to collect and utilize lessons-learned from the field. Some progressive construction firms and facilities management organizations have attempted to benefit from accumulated construction knowledge and expertise, and typically synthesize experience into a checklist. Previous efforts to effectively utilize lessons-learned were thwarted by the following:

(1) Lack of a meaningful classification system.

(2) Unmanageable format that made it difficult to access and retrieve the potentially enormous volume of lessons.

(3) Failure to effectively integrate the new scheme into the existing operations of the organization.

These challenges will be addressed in turn below.

The Classification Challenge

Principal difficulties in establishing a common classification system include the vast spectrum of potential end users and the different information each considers pertinent. The first level of divergence occurs at the phases of construction: conceptual planning, design, construction and operation/maintenance. Architects tend to group information by discipline: architectural, structural, mechanical, electrical.

Construction practitioners are more comfortable with the 16 CSI Divisions: site work, concrete, masonry, etc.

The second level of divergence relates to the many different types of constructed works. The broad categories are civil structures and buildings [Table 2.]. Civil structures run the gamut from culverts to dams to industrial complexes. Buildings span a wide range in both size and complexity, from single family homes, to high rise towers. Specialization breeds different requirements for information. The dam builder and highway contractor are both concerned with soil conditions, but each at a different level.

Another consideration is the quality or depth of the lessons. These range from superficial, or common sense (don't leave unsecured styrofoam insulation pallets on non-enclosed upper level decks on windy days) to highly technical (an M-60 machine gun firing 7.62-mm ammunition at a distance of 25 yards will not penetrate an 8" cast concrete wall with #5 rebar @ 6" on center with a 10 gauge (3.4 mm) steel front panel).

Accessibility and Retrieval of Information

While checklists of the BCO Advisor and Redicheck [Nigro, 1983] variety can be useful aids in reviewing contract plans and specifications, they do not follow the spirit of constructability. The goal is complete integration of the design/construction effort, bridging the traditional gap.

After the fact design review, implies essentially separate design and construction. To contribute to constructability, the basic unit of knowledge must be an easily accessible, specific lesson (fiberglass dome pans are superior to metal pans), not a general review recommendation (coordinate all mechanical and electrical drawings).

To be truly effective, the system must be appropriate for both designers and constructors. The lessons must be organized for rapid retrieval in a variety of ways (key words, CSI division, component). Recent advances in both hardware and software have contributed to the tools available to construct such a successful system. Lightweight, portable computers are available and easily transportable to the field, with the speed and memory to handle the demands of an enormous database. Software tools such as expert system shells and hypertext capability provide the reasoning, explanation facility and user interface essential to user acceptance. Object oriented programming, now in the early stages of development, will provide an even greater opportunity to link and access related lessons and facts in the future.

Almost all previous attempts to utilize construction feedback have followed the checklist format. In an effort to efficiently input construction knowledge back into the facility life-cycle, we will shun the checklist approach in favor of database or knowledge based expert system formats.

Integration

Perhaps most importantly, a feedback system must be integrated into the way the users (designers and constructors) perform their work. Consider this scenario: as a designer extracts a specification section on reinforced concrete, dome slab construction, from a guide specification, the lessons-learned knowledge base would automatically retrieve the applicable lessons for the designer to peruse and apply as appropriate. How about a project superintendent preparing his schedule for the following week? He knows cold weather is forecast, so he queries the system using cold weather concrete as the keyword and discovers that the mix he intended to order won't flow through the pump below a certain temperature.

Complete integration of a lessons-learned knowledge base into the existing procedures and methods of doing business is not easily achieved. There is a danger in developing a new system of any kind that requires dedicated personnel or demands large chunks of time from already overburdened schedules. Higher priorities and personnel shortages, endemic in today's economic environment, will doom a system that is not easily integrated into existing methods or procedures. For these reasons, speed, ease of use and user friendliness are pivotal in the success of a new system.

When dealing with the introduction of a new system that happens to be computer based, the major barriers are often psychological. There is a reluctance in established businesses

to relinquish manual control or to experiment with emerging technology. While lap-top personal computers may be struggling into some corporate board rooms, many project managers and superintendents are still not computer literate. This only complicates the already formidable integration challenge.

Another important aspect of integration is a grasp of the big picture, or what management specialists call vision. It is crucial to first seeing and then exploiting the potential in any feedback system. We have seen several feedback systems initiated by well intentioned, motivated, individuals that work from the perspective of their particular niche in the firm, but lack the big picture perspective. Technical sophistication is common, but adequate classification and integration are lacking. Lacking this vision, the system may serve well in it's niche, but will fail the overall organization. The goal, after all, of feedback is to achieve the widest possible dissemination and hence benefit of expert knowledge accumulated by the entire firm.

In an effort to better grasp the big picture and integration issues, we enlisted the participation of the research and development committee of a medium size construction company. Input and ideas came from various experts including field operations, project management, research, computing and accounting, construction yard and shops and upper management. The result was a confirmation of the value and direction of the feedback system.

Accentuate The Positive

Facility performance, like feedback and lessons-learned, can include both positive and negative experiences with constructed facilities. However, since most of the effort in collection and classification of performance data has been undertaken by forensic engineers, the focus has been on failures, as previously defined.

This research focuses on lessons-learned during construction. While some of the lessons will undoubtedly involve failures or incidents, the majority will convey positive experiences or advice: methods to optimize productivity, methods to obtain the flattest possible floor, optimal deck space served by a tower crane, and innovative slip form construction. The result of a knowledge based feedback system developed by construction experts will be a corporate knowledge base. The benefits of such a system are well established.

CHAPTER V - THE DEVELOPMENT OF A KNOWLEDGE BASED INFORMATION SYSTEM FOR CONSTRUCTION

As discussed in Chapter II, there are numerous potential feedback channels in the project life-cycle. The primary focus of this research has been lessons that have their genesis and application in the construction phase. While considerable effort has been exerted in developing classification and dissemination strategies almost no work has been dedicated to the construction phase.

In the construction arena, solid lessons are very difficult to extract and collect. For this reason there is a paucity of documented construction knowledge. Successful project managers and superintendents have developed their own individual methods and procedures, proven effective by their longevity in this highly competitive market. Because of their tenacity and success, it is often difficult to achieve a consensus attempting to compile the best methods, products or procedures. This difference of opinion further complicates the process of verifying and validating lessons from the field.

Many firms and organizations synthesize experience into checklists. Specific knowledge and experience is generalized into planning tools. While checklists can certainly be beneficial, other formats can optimize the value of construction feedback. We follow the constructability dictum

that early feedback of construction expertise into all phases of the project life-cycle will achieve the greatest benefits. The optimum format for such a system preserves the integrity of each individual chunk of knowledge or lesson.

The goal of this research is to develop a model of an effective lessons-learned knowledge base for a medium or large size construction firm. Essential elements of the system include (1) a meaningful classification system, (2) knowledge acquisition, or a mechanism for collecting, verifying and inputting information, and (3) implementation and integration into existing operations.

A Classification System For Construction

The goal of the classification system is to categorize all pertinent data or lessons in such a way that they can be efficiently retrieved in a number of possible manners. Since this effort is tailored for construction rather than design professionals, the basic building block of the system is the CSI Division, further defined by the component within the Division. The basic categories of data are:

A. Project Information

B. Stage of Project

C. Project Use: Structure/Civil or Building

D. CSI Division

E. Component

F. Lesson: Problem, Solution, Explanation, Key words

G. Source

The classification system model is illustrated in Figures 2 & 3. The **project information** fields would be tailored to the particular construction firm. By including the various **project stages**, the system is flexible enough to accommodate all members of a project management team. It would also be beneficial to owners of large facilities inventories and construction savvy owners, engaged in partnering.

The next level, **project use**, diverges into the two broad categories of constructed works: Structure/Civil and Buildings. The particular specialization of the construction firm would probably focus on a limited segment of **project uses**, but a representative list of possible uses is contained in Table 1. Both the component and project use breakdowns, have been adopted from the AEPIC classification system, "Dictionary of Quick Codes" shown in Appendix A.

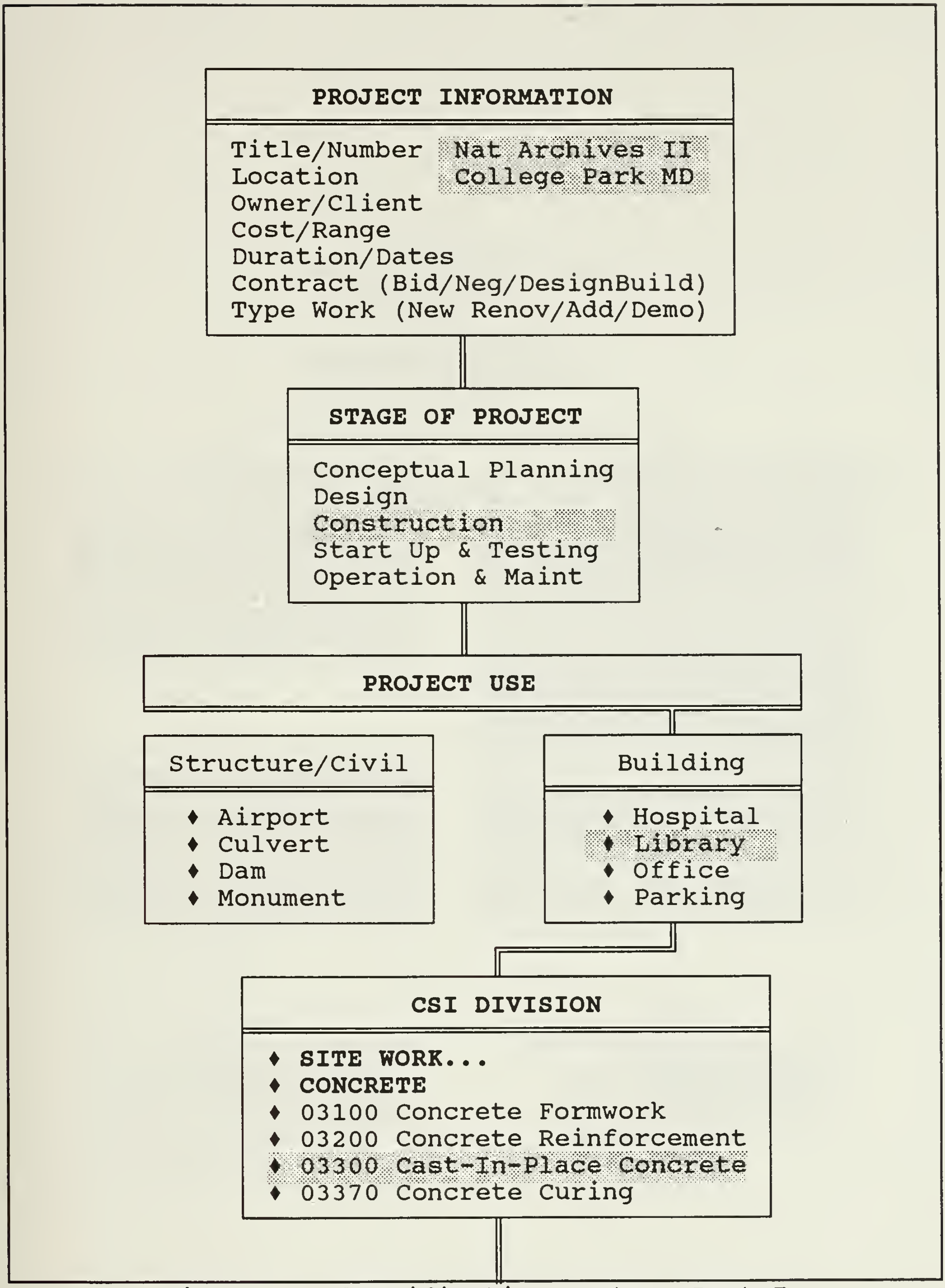

Figure 2. Classification System, Part I

COMPONENT

- **SUBSTRUCTURE**
- Footings
- Slab, On Grade
- Slab, Dome

LESSON: DOME SLAB PAN TYPE

PROBLEM: Metal pans get dented, damaged, rusty - causing imperfections in the finished concrete.

SOLUTION: Use fiberglass instead of metal pans.

EXPLANATION: Provides consistently higher quality finish when dome pans are removed.

KEY WORDS: Quality, Concr Finish, Pan forms

SOURCE

Name Ray Register Sr.
Title Superintendent
Phone Num 935-5877
Incident Date
Validated by

LESSON: DOME SLAB PAN REMOVAL

PROBLEM: Stripping stubborn pans from cured concrete can waste crew time.

SOLUTION: Make one attempt with compressed air then abandon pan in place. Return on a rain day or use idle crews to extract stragglers.

EXPLANATION: Valuable time is wasted while crew waits for one pan. Productivity suffers greatly.

KEY WORDS: Productivity, Idle time, Pan forms.

SOURCE

Name Ray Register Sr.
Title Superintendent
Phone Num 935-5877
Incident Date
Validated by

Figure 3. Classification System, Part II.

CLASSIFICATION SYSTEM - PROJECT USE

STRUCTURE/CIVIL

Special	Excavation	Retaining Wall
Airport, Nav Aid	Formwork	Scaffolding
Airfield	Foundation	Seawall
Bin, Silo	Harbor, Jetty	Sewage, Waste
Bridge, Trestle	Harbor, Terminal	Stack, Chimney
Cableway	Highway, Road	Subaqueous Str.
Comm Dish	Hoist, Crane	Swimming Pool
Causeway	Hydraulic Struct	Tank
Cemetery	Incinerator	Tower, Cooling
Containment Vessel	Irrigation Sys	Tower, Freestd.
Culvert	Lighthouse	Tower, Guyed
Dam	Monument	Tunnel, Subway
Derrick	Offshore Structure	Wall, Barrier
Dike, Levee	Park/Playing Field	Water Tower
Dock, Wharf	Parking Area	Water Processing
Drainage Works	Pipeway, Distr Sys	Waterway
Elect Generation	Railway	Reservoir
Embankment	Refinery	

BUILDINGS

Agriculture, Barn	Education, Higher	Nursing Home
Airport Terminal	Field House, Gym	Office Building
Airport Freight	Freight Terminal	Parking Structure
Apartment	Funeral Home	Postal Facility
Arena	Grocery Food Store	Public Building
Auditorium, Theater	Hospital, Special	Prison
Bank	Medical Facility	Recreation Fac.
Chemical Plant	Hotel/Motel	Refrig. Facil.
Civic Building	Housing, Duplex	Religious
Commercial, Retail	Housing, Townhouse	Restaurant
Computer Facility	Housing, Detached	Service Station,
Condominium	Industrial, Heavy	Shop Center/Mall
Convention Hall	Industrial, Light	Stadium
Courthouse	Laboratory, Research	Transportation
Dormitory	Library	Warehouse
Education, Elem, Secondary	Museum, Gallery	
	Nuclear Facility	

Table 1. Classification System, Project Use

CLASSIFICATION SYSTEM - COMPONENT	
SITE, SUBSTRUCTURE	**INTERIOR, cont**
Excavation, Grading	Horizontal Circulation
Compaction	Vertical Circulation
Sheeting	Core
Piles, Caissons	Spaces
Drainage	Surfaces
Bedding	Contents
Tunnel Lining	Ceiling
Retaining Wall	Finishes
Dam	**TEMPORARY CONSTRUCTION**
Cofferdam	Bracing
Slurry Wall	Shoring
SUBSTRUCTURE, FOUNDATION	Formwork
Abutment	Scaffolding
Footings, Line	Equipment
Footings, Mat	Fireplace
Footings, Column	Trailers
Pier	Storage Units
Wall	**MECHANICAL/ELECTRICAL SYS**
Buttress	Cooling
Pile Cap	Heating
Slab, Dome	Ventilation
Slab, On Grade	Plumbing
STRUCTURE	Lighting
Membrane	Transport
Continuous Structure	Hazard Detection
Vertical System	Emergency Power, Supply
Horizontal System	Power
Anchorage	**PAVING, LANDSCAPE**
Connection	Walkway
Joint	Roadway
Arch, Shell	Runway
Suspension	Bridge Deck
EXTERIOR ENVELOPE	Channel Lining
Paint	Trenching
Roof	Drainage
Window	Fence/Wall
Door	Plant Material (Natural)
Wall Panel	**SPECIAL CONSTRUCTION**
Insulation	Marine Installation
Waterproofing	Oil, Gas
Flashing	Tower, Stack, Chimney
Caulk, Sealant	Water Containment
Vertical Circulation	Toxic Materials Handling
Horizontal Circulation	Low Voltage Electricity
INTERIOR	High Voltage Electricity
Wall	Sewage Treatment
Floor	Crane, Boom

Table 2. Classification System, Component

CSI Division provides the general classification framework, but is still too general for pin-pointing areas of interest. **Components** within the CSI Division, Table 2, have been added to further isolate the lesson. The basic unit of the classification system is the **Lesson Learned.** It has a title, and brief narratives describing the problem, the solution, and an explanation. It is further referenced by key words to allow maximum versatility in querying the system. Finally, the Lesson is credited to a **source**, again tailored to the user institution.

The explanation facility is critical to a credible system. Telling intelligent construction practitioners that a certain method is superior to another, without providing a rationale, will not create believers. Listing the source adds credibility and provides a resource for further investigation when necessary.

Methods of Inquiry

If a user cares to peruse all the lessons pertaining to a particular type of facility, parking structures for example, he simply enters **project use**, and **buildings** then selects **parking structures** from the menu. This method can be used to gain familiarity with a new type of structure or construction method.

To learn about concrete, one can browse through the **CSI Divisions** until he finds concrete. If this topic is too broad, it can be narrowed to cast-in-place concrete by selecting **CSI** section 03300. To further narrow the search slabs or footings could be chosen from the **component** menu.

Some subjects, such as roof leaks, can occur in any number of facilities and cross many CSI Divisions. To accommodate queries of this nature, **key words** are utilized. **Key words** can also cover conditions like cold weather concreting and issues such as productivity or quality.

Knowledge Acquisition and Knowledge Engineering

Extracting expert knowledge from subject matter, or domain experts is perhaps the most difficult step in the development of any knowledge base. "Knowledge acquisition has been reported as the major bottleneck in the development of expert systems" [Bowen et al. 1990]. Experience in knowledge engineering has shown that questionnaires are not effective. For this reason, we elected to pursue unstructured interviews as the primary method of knowledge acquisition. Key issues covered during initial interviews included: existing lessons-learned systems, quality improvement initiatives, years and type of experience, areas of expertise, familiarization with computing technology and existing computer hardware and software, constructability, design-construct experience, construction performance and failures.

The goal of this research was not to accumulate a vast library of construction knowledge, but rather to collect a sample of lessons from various construction disciplines as a point of departure for the development of a classification system. The interview process itself was critical to gaining an understanding of how successful project superintendents approach their business. It allowed insight as to how they categorize, organize and utilize their rich experience. Heuristics, or rules of thumb, are plentiful in construction, but as always, difficult to articulate.

After an extensive literature search, interviews were conducted with a number of experienced construction managers, including project executives, project managers, superintendents, and foremen. Due to their hectic, unpredictable schedules, initial interviews were conducted by simply spending the day following superintendents around job sites. As areas of personal expertise became apparent, further questioning in those areas was pursued. Daily project dilemmas provided other opportunities to gain insight into frequently applied heuristics and problem solving mechanisms. It was immediately apparent that extraction of valuable lessons requires much patience and persistence.

The classification system was developed based on the format these construction experts used to articulate their rules of thumb. For example, when discussing how much concrete to leave in the hopper of a pump truck, the discussion took

place in the context of a particular facility (PROJECT USE). The facility was essentially built from reinforced concrete (CSI DIVISION), the COMPONENT was a topping slab, and the method was pumping (LESSON TITLE). The lesson itself consisted of a brief narrative description of the problem, the solution and an explanation. To accommodate broad issues that span many divisions or trades, such as the quality of the finished concrete, KEY WORDS were included.

Collection and verification methods that rely on the good will of potential users to input applicable information when they have time to do it, have proven ineffective. A structured approach to data input and verification is essential. Routine status reports and meetings as well as various project milestones, provide the ideal opportunity to reflect upon and input lessons-learned.

Based on this research, it is apparent that a dedicated collector of lessons will be required to establish a working prototype. The frantic pace of operations at the project site requires an individual free of daily project pressures to concentrate on building the firm foundation required for such a system. Once a prototype has been developed, it can be demonstrated to potential users. The ease of use and potential benefits will help sell the system to the users, encourage experimentation and lead to faster acceptance of the system. It is imperative to establish a credible prototype with which to lure in skeptical users and reluctant experts.

Implementation Issues

The myriad of potential lessons-learned and construction knowledge can be organized, stored and accessed most efficiently utilizing knowledge processing and hypermedia techniques. The heuristics (rules of thumb based on experience) gathered from construction experts can be organized using the classification system and incorporated into a knowledge base. The result of this task is a common pool for storing, retrieving, modifying, interpreting and reasoning with constructability knowledge.

The first function of the system will be to obtain the project of interest. This single piece of data will cause the system to link to a block of applicable rules. Entry of the World Bank project, for example, would trigger project use data and link to multi-story, cast in place concrete structure, multi-level basement, severely constricted site. This information would activate rules dealing with multi-story concrete structures etc. Rules about steel frame structures would not be activated, while rules about slurry wall construction, and soil anchors would be activated. This linkage of basic project data serves as a first cut to narrow down the field of potentially useful lessons.

The next step would be to query the user for the situation at hand. Information regarding the stage of construction, applicable CSI Divisions, and work component would be solicited by sequential menus. This will provide a

direct link to the classification system, accessing all applicable rules.

The user interface is a critical component to any interactive system. In this case, it is essential to provide the user with an explanation facility. Without such a capability, the integrity of the system is suspect to the new user. A basis for each particular lesson is required, relating to time, cost or quality. This explanation facility will also prove indispensable when debugging or validating the system as it evolves from a prototype to a mature system.

Wherever they exist, alternative solutions to problem situations should be provided. There generally is not one unique, universally accepted solution to any construction predicament, and an alternate solution may be more appropriate considering the peculiarities of a given situation.

Software. A wide variety of database application software is commercially available. Most are programmable to some extent and all can be customized for individual applications. The emerging technology that is best suited for a lessons-learned knowledge base, however, is expert system shells. BCO Advisor, discussed in Chapter III, employed such software. A review of currently available, microcomputer-based expert system shells (ESS) suggests several suitable options. KNOWLEDGE-PRO, LEVEL 5 OBJECT, KAPPA PC, and VP EXPERT all offer hypertext capability, windowed interface, advanced programming capabilities and rule based knowledge

representation. Because new products are being introduced monthly, it is difficult to make definitive recommendations. The essential elements of an ESS for this application would be hypertext capability, windowing capability, rule or frame based reasoning and possibly object oriented programming.

CHAPTER VI - CONCLUSION

Historically, the collection and dissemination of engineering/construction knowledge has proven to be difficult but invaluable when accomplished. The main contribution of this research has been to demonstrate the feasibility and potential benefits of making effective use of construction lessons-learned by developing a knowledge based model from actual construction experience. Key challenges to effectively utilizing feedback channels in the project life-cycle were identified along with methods to meet these challenges.

The CII has called for improved documentation of lessons-learned from the field. The model presented in this thesis will accomplish this goal. The benefits of an effective feedback system are numerous. Although construction of a facility is typically viewed as a one of a kind operation, there is a considerable amount of repetition. Facades, bays and often entire floors are repeated. Lessons acquired in one project by a particular crew, must be communicated to other crews on the same project as well as to other projects. As the CII advocates, a corporate lessons-learned database is a key element in any constructability program.

The significance of such a system is not limited to improvements in cost, time, quality and safety of construction projects. It will also enhance construction education by

providing students with fresh examples from actual construction projects.

APPENDIX A

AEPIC DICTIONARY OF QUICK CODES

DICTIONARY OF QUICK CODES

ARCHITECTURE AND ENGINEERING PERFORMANCE INFORMATION CENTER

(Information Not Available XX; None 00)

A. DATA

SOURCE DS

10 **AEPIC**
20 **FIRMS**
21 Architecture and A/E
22 Landscape Architecture
23 Engineering and E/A
24 Land Engineer
25 Construction
26 Owner
27 Legal
28 Insurance
29 Testing
30 Manufacture
31 Supply/Distribution
32 Land Surveyor
33 Forensics
34 Construction Management
35 Quantity Surveyor/Estimator

40 **SOCIETIES/ASSOCIATIONS/ INSTITUTIONS**
41 Architecture
42 Landscape Architecture
43 Engineer
44 Land Engineer
45 Construction
46 Owners
47 Legal
48 Insurance
49 Testing
50 Manufacture
51 Supply/Distribution
52 Land Surveyor
53 Education

60 **PUBLICATIONS/MEDIA**
61 Technical
62 Professional
63 Popular
70 **GOVERNMENT**
71 Federal
72 State
73 Local
74 Foreign

TYPE DT

01 Article, Published
02 Bibliography, Search Index
03 Conference Report, Proceeding
04 Directory, Dictionary
05 Environmental Analyses, Filing
06 Financial Report, Fiscal Matter
07 Guide, Handbook
08 Hearing, History
09 Investigation, Inspection, Research
10 Journal, Collected Case Histories
11 Contract, Agreement
12 Law, Legislative Document

13 Major Dossier, Case, Claims Document
14 Map
15 Opinion, Case Law, Decision, Ruling, Dicta
16 Policy Statement, Position Paper
17 Model
18 Regulation, Rule
19 Specification, Code
20 Trial, Litigation, Brief, Memorandum

21 Textbook
22 Photo, Slide
23 Drawing
24 Film, Video
25 Working Paper, Analysis
26 Exhibit
27 Yearbook
28 Graph
29 Interview

CLASS DC

01 Design
02 Construction
03 Testing, Research
04 Structure

05 Materials, Products
06 Information Science, Computers
07 Legal Matters
08 Insurance, Risk Management

09 Finance Statistics
10 Quality Control
11 Quality Assessment

B. LOCATION

COUNTRY OR STATE IN WHICH DAMAGE OCCURRED LD

COUNTRY OR STATE OF FIRM'S OFFICE LF

AF	Afghanistan
AL	Albania
AG	Algeria
AQ	American Samoa
AN	Andorra
AO	Angola
AV	Anguilla
AY	Antarctica
AC	Antigua & Barbuda
AR	Argentina
AT	Ashmore & Cartier Is
AS	Australia
AU	Austria
BF	Bahamas
BA	Bahrain
FQ	Baker Is
BG	Bangladesh
BB	Barbados
BS	Bassas De India
BE	Belgium
BH	Belize
BN	Benin
BD	Bermuda
BT	Bhutan
BL	Bolivia
BC	Botswana
BV	Bouvet Is
BR	Brazil
IO	Brit Indian Ocean Terr
VI	Brit Virgin Is
BX	Brunei
BU	Bulgaria
BM	Burma
BY	Burundi
CM	Cameroon
CA	Canada
CV	Cape Verde
CJ	Cayman Is
CT	Central African Republic
CD	Chad
CI	Chile
CH	China
KT	Christmas Is
IP	Clipperton Is
CK	Cocos (Keeling) Is
CO	Columbia
CN	Comoros
CF	Congo
CW	Cook Is
CR	Coral Sea Is
CS	Costa Rica
CU	Cuba
CY	Cyprus
CZ	Czechoslovakia
DA	Denmark
DJ	Dyibouti
DO	Dominica
DR	Dominican Republic
EC	Ecuador
EG	Egypt
ES	El Salvador
EK	Equatorial Guinea
ET	Ethiopia
EU	Europa Is
FO	Foroe Is
FA	Falkland Is
FJ	Fiji
FI	Finland
FR	France
FG	French Guiana
FP	French Polynesia
FS	French S & Antarc Lands
GB	Gabon
GA	Gambia
GZ	Gaza Strip
GC	German Dem Rep
BZ	Germany, Berlin
GE	Germany, Fed Rep
GH	Ghana
GI	Gibraltar
GO	Glorioso Is
GR	Greece
GL	Greenland
GJ	Grenada
GP	Guadaloupe
GQ	Guam
GT	Guatemala
GK	Guernsey
GV	Guinea
PU	Guinea-Bissau
GY	Guyana
HA	Haiti
HM	Heard Is & McDonald
HO	Honduras
HK	Hong Kong
HQ	Howland Is
HU	Hungary
IC	Iceland
IN	India
ID	Indonesia
IR	Iran
IZ	Iraq
IY	Iraq-Saudi Ar Neut Zn
EI	Ireland
IS	Israel
IT	Italy
IV	Ivory Coast
JM	Jamaica
JN	Jan Mayen
JA	Japan
DQ	Jarvis Is
JE	Jersey
JQ	Johnston Atoll
JO	Jordan
JU	Juan De Nova Is
CB	Kampuchia
KE	Kenya
KQ	Kingman Reef
KR	Kiribati
KN	Korea Dem Peop Rep
KS	Korea Rep
KU	Kuwait
LA	Laos
LE	Lebanon
LT	Lesotho
LI	Liberia
LY	Libya
LS	Liechtenstein
LU	Luxembourg
MC	Macau
MA	Madagascar
MI	Malawi
MY	Malaysia
MV	Maldives
ML	Mali
MT	Malta
IM	Man, Isle Of
MB	Martinique
MR	Mauritania
MP	Mauritius
MF	Mayotte
MX	Mexico
MQ	Midway Is
MN	Monaco
MG	Mongolia
MH	Montserrat
MO	Morocco
MZ	Mozambique
WA	Namibia
NR	Nauru
BQ	Navassa Is
NP	Nepal
NL	Netherlands
NA	Netherlands Antilles
NC	New Calendonia
NZ	New Zealand
NU	Nicaragua
NG	Niger
NI	Nigeria
NE	Niue
NF	Norfolk
CQ	Northern Mariana Is
NO	Norway
MU	Oman
PK	Pakistan
LQ	Palmyra Atoll
PM	Panama
PP	Papua New Guinea
PF	Paracel Is
PA	Paraguay
PE	Peru
RP	Philippines
PC	Pitcairn Is
PL	Poland
PO	Portugal
RQ	Puerto Rico
QA	Qatar
RE	Reunion
RO	Romania
RW	Rwanda
SC	St Christopher & Nevis
SH	St Helena
ST	St Lucia
SB	St Pierre & Miquelon
VC	St Vincent & Grenadines
SM	San Marino
TP	Sao Tome & Principe
SA	Saudi Arabia
SG	Senegal
SE	Seychelles
SL	Sierra Leone
SN	Singapore
BP	Solomon Is
SO	Somalia
SF	South Africa
SP	Spain
PG	Spratly Is
CE	Sri Lanka

SU	Sudan	NQ	Trust Terr Of Pacific Is	VM	Vietnam
NS	Suriname	TS	Tunisia	VQ	Virgin Is Of US
SV	Svalbard	TU	Turkey	WQ	Wake Is
WZ	Swaziland	TK	Turks & Caicos Is	WF	Wallis & Fortuna
SW	Sweden	TV	Tuvalu	WE	West Bank
SZ	Switzerland	UG	Uganda	WI	Western Sahara
SY	Syria	UR	Union Of Soviet Soc Reps	WS	Western Samoa
TW	Taiwan	TC	United Arab Emirates	YS	Yemen (Aden)
TZ	Tanzania, Un Rep	UK	United Kingdom	YE	Yemen (Sanaa)
TH	Thailand	US	United States Of America	YO	Yugoslavia
TO	Togo	UV	Upper Volta	CC	Zaire
TL	Tokelay	UY	Uruguay	ZA	Zambia
TN	Tonga	NH	Vanuatu (New Hebrides)	ZI	Zimbabwe
TD	Trinidad And Tobago	VT	Vatican City		
TE	Tromelin Is	VE	Venezuela		

UNITED STATES

01	(AL)	Alabama	18	(KY)	Kentucky	35	(ND)	North Dakota
02	(AS)	Alaska	19	(LA)	Louisiana	36	(OH)	Ohio
03	(AZ)	Arizona	20	(ME)	Maine	37	(OK)	Oklahoma
04	(AK)	Arkansas	21	(MD)	Maryland	38	(OR)	Oregon
05	(CA)	California	22	(MA)	Massachusetts	39	(PA)	Pennsylvania
06	(CO)	Colorado	23	(MI)	Michigan	40	(RI)	Rhode Island
07	(CT)	Connecticut	24	(MN)	Minnesota	41	(SC)	South Carolina
08	(DE)	Delaware	25	(MS)	Mississippi	42	(SD)	South Dakota
09	(DC)	District Of Columbia	26	(MO)	Missouri	43	(TN)	Tennessee
10	(FL)	Florida	27	(MT)	Montana	44	(TX)	Texas
11	(GA)	Georgia	28	(NB)	Nebraska	45	(UT)	Utah
12	(HI)	Hawaii	29	(NV)	Nevada	46	(VT)	Vermont
13	(ID)	Idaho	30	(NH)	New Hampshire	47	(VA)	Virginia
14	(IL)	Illinois	31	(NJ)	New Jersey	48	(WA)	Washington
15	(IN)	Indiana	32	(NM)	New Mexico	49	(WV)	West Virginia
16	(IA)	Iowa	33	(NY)	New York	50	(WS)	Wisconsin
17	(KS)	Kansas	34	(NC)	North Carolina	51	(WY)	Wyoming

C. PROJECT

TYPE PT

01 Building
O2 Structure/Civil
03 Landscape

MATERIAL PM

01 Steel
02 Cast Iron
03 Wrought Iron
04 Aluminum
05 Other Metal
06 Precast Concrete
07 Poured In Place Concrete
08 Stone
09 Concrete Block
10 Brick
11 Asphalt
12 Earth Work
13 Wood/Timber
14 Prestressed Concrete
15 Masonry (unspecified)
16 Prestressed Masonry

STRUCTURAL SYSTEM PS

01 Footing
02 Caisson
03 Pilings
04 Tubular
05 Column
06 Pier
07 Bearing Wall
08 Beam
09 Girder
10 Grid
11 Slab
12 Frame
13 Arch
14 Vault
15 Dome
16 Pneumatic
17 Tension Membrane
18 Tension Cable
19 Shell
20 Folded-Plate
21 Truss
22 Space Truss
23 Continuous
24 Berm/Fill/Grading

USE PU

STRUCTURE/CIVIL

101	Special
102	Airport, Nav Aid, Fueling
103	Airfield Paving
104	Bin, Silo
105	Bridge, Trestle, Viaduct
106	Cableway
107	Communications Dish
108	Causeway
109	Cemetery
110	Containment Vessel
111	Culvert
112	Dam
113	Derrick
114	Dike, Levee
115	Dock, Wharf
116	Drainage Works
117	Electricity Generation
118	Embankment
119	Excavation
120	Formwork, Shoring
121	Foundation Structure
122	Harbor, Jetty, Pier
123	Harbor, Terminal
124	Highway, Road
125	Hoist, Crane
126	Hydraulic Structure
127	Incinerator
128	Irrigation System
129	Lighthouse
130	Monument
131	Offshore Structure
132	Park/Playing Field
133	Parking Area
134	Pipeway, Distribution System
135	Railway
136	Refinery
137	Retaining Wall
138	Scaffolding
139	Seawall, Breakwater
140	Sewage/Waste Processing
141	Stack, Chimney
142	Subaqueous Structure
143	Swimming Pool
144	Tank
145	Tower, Cooling
146	Tower, Freestanding
147	Tower, Guyed
148	Tunnel, Subway
149	Wall, Barrier
150	Water Tower
151	Water Processing
152	Waterway
153	Reservoir

BUILDINGS

553	Agriculture, Barn
554	Airport Terminal, Hanger
555	Airport Freight, Storage
556	Apartment
557	Arena
558	Auditorium, Theatre
559	Bank
560	Chemical Plant
561	Civic BuildingS
562	Commercial, Retail
563	Computer Facility
564	Condominium
565	Convention Hall
566	Courthouse
567	Dormitory
568	Education, Elementary, Secondary
569	Education, Higher Education
570	Field House, Gymnasium
571	Freight Terminal
572	Funeral Home
573	Grocery Food Store
574	Hospital Special Medical Facility
575	Hotel/Motel
576	Housing, Duplex
577	Housing, Townhouse
578	Housing, Detached
579	Industrial, Heavy
580	Industrial, Light
581	Laboratory, Research
582	Library
583	Museum, Gallery
584	Nuclear Facility
585	Nursing Home
586	Office Building
587	Parking Deck, Structure
588	Postal Facility
589	Public Building
590	Prison, Correctional
591	Recreational Facility
592	Refrigeration Facility
593	Religious
594	Restaurant
595	Service Station, Garage
596	Shopping Center/Mall
597	Stadium
598	Transportation Terminal
599	Warehouse

CLASSIFICATION PC

01 New/Original
02 Renovation/Retrofit
03 Addition
04 Demolition

DIMENSIONS OF PROJECT (Rounded To Nearest Unit)

LENGTH PL
WIDTH/CROSS SECTION PW
HEIGHT PH
BAY SPAN PB
LONGEST SPAN PX

FRACTIONS OF AN INCH

001	1/16th	Inch
002	1/8th	Inch
003	3/16th	Inch
004	1/4th	Inch
005	5/16th	Inch
006	3/8th	Inch
007	7/16th	Inch
008	1/2th	Inch
009	9/16th	Inch
010	5/8th	Inch
011	11/16th	Inch
012	3/4th	Inch
013	13/16th	Inch
014	7/8th	Inch
015	15/16th	Inch

INCHES

101-199 (1 - 99) Inches

FEET

201-299 (1-99) Feet
301-399 (1-99) Hundred Feet

MILES

401-498 (1-98) Miles
499 (>99) Miles
(Please note in abstract any miles over 99)

DATE

YEAR OF DESIGN COMMISSION PY
MONTH/DAY PP
YEAR OF CONSTRUCTION COMMISSION PR
MONTH/DAY PO
YEAR OF OCCUPANCY/PUBLIC USE PS
MONTH/DAY PN

YEAR
(State actual year)

MONTH
01-12 January - December

DAY
01-31 (1-31)

SEASONS
2001 Spring
2002 Summer
2003 Fall
2004 Winter

DURATION
3001-3999 Actual Months Duration (1-999)
4001-4999 Actual Years Duration (1-999)

COST PD

0001-0999 (1 - 999) Dollars
1001-1999 (1 - 999) Thousand Dollars
2001-2999 (1 - 999) Million Dollars
3001-3999 (1 - 999) Billion Dollars

D. INCIDENT/PROBLEM

TYPE IT

01 Property Damage (If None Skip F)
02 Bodily Injury (If None Skip G)
03 Management/Delivery Of Services (If None Skip H)

DATE

YEAR INCIDENT NOTICED IY
MONTH/DAY IM
YEAR INCIDENT NOTIFICATION MADE IR
MONTH/DAY IO

YEAR
(State actual year)

MONTH
01-12 January - December

DAYS
01-31 (1-31)

SEASONS
2001 Spring
2002 Summer
2003 Fall
2004 Winter

DURATION
3001-3999 Actual Months Duration (1-999)
4001-4999 Actual Years Duration (1-999)

E. COMPONENT

CSI REFERENCE CODE C

00010 Pre-Bid Information
00100 Instructions To Bidders
00200 Information Available Bidders
00300 Bid Forms
00400 Supplements To Bid Forms
00500 Agreement Forms
00600 Bonds And Certificates
00700 General Conditions
00800 Supplementary Conditions
00850 Drawings and Schedules
00900 Addenda And Modifications

GENERAL REQUIREMENTS
01010 Summary Of Work
01020 Allowances
01025 Measurement And Payment
01030 Alternates/Alternatives
01040 Coordination
01050 Field Engineering
01060 Regulatory Requirements
01070 Abbreviations And Symbols
01080 Identification Systems
01090 Reference Standards
01100 Special Project Procedures
01200 Project Meetings
01300 Submittals
01400 Quality Control
01500 Construction Facilities And Temporary
01600 Material And Equipment
01650 Starting Of Systems/ Commissioning
01700 Contract Closeout
01800 Maintenance

SITE WORK
02010 Subsurface Exploration
02050 Demolition
02100 Site Preparation
02140 Dewatering
02150 Shoring And Underpinning
02160 Excavation Support Systems
02170 Cofferdams
02200 Earthwork
02300 Tunneling
02350 Piles And Caissons
02450 Railroad Work
02480 Marine Work
02500 Paving And Surfacing
02600 Piped Utility Materials
02660 Water Distribution
02680 Fuel Distribution
02700 Sewerage And Drainage
02760 Restoration Of Underground Pipelines
02770 Ponds And Reservoirs
02780 Power And Communications
02800 Site Improvements
02900 Landscaping

CONCRETE
03100 Concrete Formwork
03200 Concrete Reinforcement
03250 Concrete Accessories
03300 Cast-In-Place Concrete
03370 Concrete Curing
03400 Precast Concrete
03500 Cementitious Decks
03600 Grout
03700 Concrete Restoration/Cleaning
03800 Mass Concrete

MASONRY
04100 Mortar
04150 Masonry Accessories
04200 Unit Masonry
04400 Stone
04500 Masonry Restoration And Cleaning
04550 Refractories
04600 Corrosion Resistant Masonry

METALS
05010 Metal Materials
05030 Metal Finishes
05050 Metal Fastening
05100 Structural Metal Framing
05200 Steel Joists
05300 Metal Decking
05400 Cold-Formed Metal Framing
05500 Metal Fabrications
05580 Sheet Metal Fabrications
05700 Ornamental Metal
05800 Expansion Control
05900 Hydraulic Structures

WOOD AND PLASTICS
06050 Fasteners And Adhesives
06100 Rough Carpentry
06130 Heavy Timber Construction
06150 Wood-Metal Systems
06170 Prefabricated Structural Wood
06200 Finish Carpentry
06300 Wood Treatment
06400 Architectural Woodwork
06500 Prefabricated Structural Plastics
06600 Plastic Fabrications

THERMAL MOISTURE PROTECTION
07100 Waterproofing
07150 Dampproofing
07190 Vapor And Air Retarders
07200 Insulation
07250 Fireproofing
07300 Shingles And Roofing Tiles
07400 Preformed Roofing And Cladding/Siding
07500 Membrane Roofing
07570 Traffic Topping
07600 Flashing And Sheet Metal
07700 Roof Specialties And Accessories
07800 Skylights
07900 Joint Sealers

DOORS AND WINDOWS
08100 Metal doors And Frames
08200 Wood And Plastic Doors
08250 Door Opening Assemblies
08300 Special Doors
08400 Entrances And Storefronts
08500 Metal Windows
08600 Wood And Plastic Windows
08650 Special Windows
08700 Hardware
08800 Glazing
08900 Glazed Curtain Walls

FINISHES
09100 Metal Support Systems
09200 Lath And Plaster
09230 Aggregate Coatings
09250 Gypsum Board
09300 Tile
09400 Terrazzo
09500 Acoustical Treatment
09540 Special Surfaces
09550 Wood Flooring
09600 Stone Flooring
09630 Unit Masonry Flooring
09650 Resilient Flooring
09680 Carpet
09700 Special Flooring
09780 Floor Treatment
09800 Special Coatings
09900 Painting
09950 Wall Coverings

SPECIALTIES
10100 Chalkboards And Tackboards
10150 Compartment And Cubicals
10200 Louvers And Vents
10240 Grilles And Screens
10250 Service Wall Systems
10260 Wall And Corner Guards
10270 Access Flooring
10280 Specialty Modules
10290 Pest Control
10300 Fireplaces And Stoves
10340 Prefabricated Exterior Specialties
10350 Flagpoles
10400 Identifying Devices
10450 Pedestrian Control Devices
10500 Lockers
10520 Fire Protection Specialties
10530 Protective Covers
10550 Postal Specialties
10600 Partitions
10650 Operable Partitions
10670 Storage Shelving
10700 Exterior Sun Control Devices
10750 Telephone Specialties
10800 Toilet And Bath Accessories
10880 Scales
10900 Wardrobe/Closet Specialties

EQUIPMENT
11010 Maintenance Equipment
11020 Security And Vault Equipment
11030 Teller And Service Equipment
11040 Ecclesiastical Equipment
11050 Library Equipment
11060 Theater And Stage Equipment
11070 Instrumental Equipment
11080 Registration Equipment
11090 Checkroom Equipment
11100 Mercantile Equipment
11110 Commercial Laundry And Dry Cleaning
11120 Vending Equipment
11130 Audio-Visual Equipment
11140 Service Station Equipment

11150 Parking Control Equipment
11160 Loading dock Equipment
11170 Solid Waste Handling Equipment
11190 Detention Equipment
11200 Water Supply And Treatment Equipment
11280 Hydraulic Gates And Valves
11300 Fluid Waste Treatment Equipment
11400 Food Service Equipment
11450 Residential Equipment
11460 Unit Kitchens
11470 Darkroom Equipment
11480 Athletic, Recreational And Therapeutic Equipment
11500 Industrial/Process Equipment
11600 Laboratory Equipment
11650 Planetarium Equipment
11660 Observatory Equipment
11700 Medical Equipment
11780 Mortuary Equipment
11850 Navigation Equipment

FURNISHINGS
12050 Fabrics
12100 Artwork
12300 Manufactured Casework
12500 Window Treatment
12600 Furniture And Accessories
12670 Rugs And Mats
12700 Multiple Seating
12800 Interior Plants And Planters

SPECIAL CONSTRUCTION
13010 Air supported Structures
13020 Integrated Assemblies
13030 Special Purpose Rooms
13080 Sound, Vibration, And Seismic Control
13090 Radiation Protection
13100 Nuclear Reactors
13120 Pre-Engineered Structures
13150 Pools
13160 Ice Rinks
13170 Kennels And Animal Shelters
13180 Site Constructed Incinerators
13200 Liquid And Gas Storage Tanks
13220 Filter Underdrains And Media
13230 Digestion Tank Covers And Appurtenances
13240 Oxygenation Systems
13260 Sludge Conditioning Systems
13300 Utility Control Systems
13400 Industrial And Process Control Systems
13500 Recording Instrumentation
13550 Transportation Control Instrumentation
13600 Solar Energy Systems
13700 Wind Energy Systems
13800 Building Automation Systems
13900 Fire Suppression And Supervisory Systems

CONVEYING SYSTEMS
14100 Dumbwaiters
14200 Elevators
14300 Moving Stairs And Walks
14400 Lifts
14500 Material Handling Systems
14600 Hoists And Cranes
14700 Turntables
14800 Scaffolding
14900 Transportation Systems

MECHANICAL
15050 Basic Mechanical Materials And Methods
15250 Mechanical Insulation
15300 Fire Protection
15400 Plumbing
15500 Heating, Ventilating, And Air Conditioning (HVAC)
15550 Heat Generation
15650 Refrigeration
15750 Heat Transfer
15850 Air Handling
15880 Air Distribution
15950 Controls
15990 Testing, Adjusting, And Balancing

ELECTRICAL
16050 Basic Mechanical Materials And Methods
16200 Power Generation
16300 High Voltage Distribution (Above 600-Volt)
16400 Service And Distribution (600-Volt And Below)
16500 Lighting
16600 Special Systems
16700 Communications
16850 Electric Resistance Heating
16900 Controls
16950 Testing

COMPONENT/ELEMENT CE

110 **SITE, SUBSTRUCTURE**
111 Excavation, Grading, Compaction
112 Sheeting
113 Piles, Caissons
114 Drainage
115 Bedding
116 Tunnel Lining
117 Retaining Wall
118 Dam
119 Cofferdam
220 **SUBSTRUCTURE, FOUNDATION**
221 Footings, Line
222 Footings, Mat
223 Footings, Column
224 Pier
225 Wall
226 Buttress
227 Pile Cap
228 Abutment
229 Slab
330 **STRUCTURE**
331 Vertical System
332 Horizontal System
333 Continuous Structure
334 Anchorage
335 Connection
336 Joint
337 Arch, Shell
338 Suspension
339 Membrane
440 **EXTERIOR, ENVELOPE**
441 Window
442 Door
443 Roof
444 Wall Panel
445 Insulation
446 Waterproofing
447 Flashing
448 Caulk, Sealant
449 Paint
450 Horizontal Circulation
451 Vertical Circulation
550 **INTERIOR**
551 Wall
552 Floor
553 Ceiling
554 Horizontal Circulation
555 Vertical Circulation
556 Core
557 Spaces
558 Surfaces
559 Contents
660 **TEMPORARY CONSTRUCTION**
661 Bracing
662 Shoring
663 Formwork
664 Scaffolding
665 Equipment
666 Fireplace
667
668
669
770 **MECHANICAL/ELECTRICAL SYSTEMS**
771 Cooling
772 Heating
773 Ventilation
774 Plumbing
775 Lighting
776 Transport
777 Hazard Detection, Protection
778 Emergency Power, Supply
779 Power
880 **PAVING, LANDSCAPE**
881 Walkway
882 Roadway
883 Runway
884 Bridge Deck
885 Channel Lining
886 Trenching
887 Drainage
888 Fence/Wall
889 Plant Material (Natural)
990 **SPECIAL CONSTRUCTION**
991 Marine Installation
992 Oil, Gas, Other Installation
993 Tower, Stack, Chimney
994 Water Containment
995 Toxic Materials Handling
996 Low Voltage Electricity
997 High Voltage Electricity
998 Sewage Treatment
999 Crane, Boom

COMPONENT MATERIAL CM
SUB-SYSTEM MATERIAL CS

01 Steel, Steel Components	09 Paint	17 Wood
02 Other Metals, Alloys	10 Coatings	18 Interior Coverings
03 Cement, Mortar	11 Sealants	19 Finishes
04 Masonry	12 Plastic	20 Synthetics
05 Concrete, Mineral Aggregates	13 Rubber	21 Equipment
06 Glass	14 Membrane	22 Fiber/Insulative Material
07 Tile, Ceramics	15 Building Stone	23 Gravel, Crushed Rock
08 Bituminous, Asphalt	16 Earthworks	

DIMENSIONS OF COMPONENT (Rounded To Nearest Unit)

LENGTH CL
WIDTH/CROSS SECTION CW
HEIGHT CH
BAY SPAN CB

FRACTIONS OF AN INCH

001 1/16th Inch
002 1/8th Inch
003 3/16th Inch
004 1/4th Inch
005 5/16th Inch
006 3/8th Inch
007 7/16th Inch
008 1/2th Inch
009 9/16th Inch
010 5/8th Inch
011 11/16th Inch
012 3/4th Inch
013 13/16th Inch
014 7/8th Inch
015 15/16th Inch

INCHES

101-199 (1 - 99) Inches

FEET

201-299 (1-99) Feet
301-399 (1-99) Hundred Feet

MILES

401-498 (1-98) Miles
499 (>99) Miles
(Please note in abstract any miles over 99)

F. PROPERTY DAMAGE/EFFECT

CATALYST EY

01 Loads	06 Condensation	11 Fire
02 Cold	07 Vibration	12 Maintenance
03 Heat	08 Impact	13 Earthquake
04 Wind	09 Equipment	14 Corrosion
05 Water	10 Soils	15 Flammables/Liquid, Gas

RESULT/EFFECT ER

01 Cosmetic/Aesthetic	07 Acoustical Impairment	13 Significant Collapse/Destruction
02 Cracks	08 Plumbing Malfunction	14 Interior/Spatial Dysfunction
03 Moisture Penetration	09 Environmental Dysfunction	15 Fire/Explosion
04 Infiltration/Thermal	10 Deformation	16 Falling Objects
05 Mechanical Malfunction	11 Movement/Deflection	17 Inundation/Liquid, Water
06 Electrical Malfunction	12 Partial Collapse	

COST TO REMEDY ED

0001-0999 (1 - 999) Dollars
1001-1999 (1 - 999) Thousand Dollars
2001-2999 (1 - 999) Million Dollars
3001-3999 (1 - 999) Billion Dollars

G. BODILY INJURY/DEATHS

PHASE OF ACCIDENT BA

01 Construction	02 Occupancy	03 Demolition

LOCATION OF ACCIDENT BL

01 Roof	11 Window	21 Plumbing Apparatus
02 Floor	12 Door	22 Platform
03 Hallway	13 Pool	23 Sidewalk
04 People Mover	14 Special Room	24 Parking Lot
05 Bridgeway	15 Furniture	25 Roadway
06 Escalator	16 Fixture	26 Scaffolding
07 Elevator	17 Tool	27 Tunnel
08 Stair	18 Machines	28 Trench
09 Ramp	19 Electrical Apparatus	29 Construction Equipment
10 Ladder	20 Mechanical Apparatus	30 Maintenance Equipment

TYPE OF PERSON(S) BP

01 Construction Worker	02 Building Worker	03 Public/User

CATALYST BC

01 Oily	07 Uneven	13 Safety Precautions
02 Wet	08 Openings	14 Hot
03 Slippery	09 Debris	15 Cold
04 Fixed Object	10 Weakness	16 Wind/Lateral Pressure
05 Rough	11 Insecurity	
06 Broken	12 Pollutants	

RESULT BR

01 Fall	05 Collision	09 Collapse Including Falling Objects
02 Burial	06 Exposure	10 Fire
03 Electrocution	07 Explosion	
04 Trip	08 Falling Object/No Collapse	

DEATHS BD
INJURIES BI

0001-0999 (1-9,999) Persons (Please note in abstract all deaths and/or injuries over 10,000)

BA/BC/BD/BI/BL/BP/BR

H. MANAGEMENT/DELIVERY OF SERVICES

DELAY MD

01-98 (1-98) Months
99 (>99) Months

(Please note in abstract all delays over 99 Months)

OVERRUN MO
EXTRAS ME

0001-0999 (1 - 999) Dollars
1001-1999 (1 - 999) Thousand Dollars
2001-2999 (1 - 999) Million Dollars
3001-3999 (1 - 999) Billion Dollars

STAGE MS

01 Permits, Liens
02 Design
03 Equipment
04 Site Preparation
05 Construction
06 Punch List
07 Occupancy

CATALYST/PERSON MC

01 Surveyor
02 Designer
03 Contractor
04 SubContractor
05 Owner
06 Manufacturer
07 Labor (Strike)
08 Material Supply, Distrib (Shortage)

I. PARTIES INVOLVED

ALLEGED DEFENDANT/RESPONSIBLE PARTY FD
CLAIMANT/PLAINTIFF/CONCERNED PARTY FP

01 Architect
02 Landscape Architect
03 Interior Designer
04 Planner/Urban Designer
05 Architect/Engineer
06 Engineer/Architect
07 Structural
08 Civil
09 Mechanical
10 Electrical
11 Geological
12 Contractor
13 SubContractor
14 Construction Worker
15 Building Worker/Employee
16 Fabricator/Manufacturer
17 Distributor/Supplier
18 Surveyor
19 Insurance Company
20 Owner
21 Unrelated Individual
22 Developer
23 Federal Government
24 State Government
25 Local Government

SIZE OF RESPONSIBLE FIRM/DEFENDANT FS

0001-0999 (1 - 999) Persons
1001-1999 (1 - 999) Thousand Persons

OWNER OF PROJECT FO

01 Federal Government
02 State Government
03 Local Government
04 Non-Profit Organization
05 Profit Organization
06 Speculative Developer
07 Design/Build
08 Partnership
09 Joint Venture
10 Individual
11 Foreign Government

J. SERVICES

TYPE OF SERVICES RELATING TO PROBLEM SP

01 Architectural
02 Structural
03 Civil
04 Mechanical
05 Electrical
06 Geological
07 Surveying
08 Construction
09 Fabrication
10 Distribution/Supply
11 Landscape

TYPE OF DESIGN CONTRACT SC

01 AIA/NSPE
02 ACEC
03 Federal
04 State
05 Military
06 Other Written
07 Oral
08 Local Government

TYPE OF SERVICES RELATING TO CONTRACT SR

01 Survey
02 Bid/Estimates
03 Study/Report/Testing
04 Basic/Full Services
05 Plans, Specifications
06 Shop Drawings
07 Design Drawings
08 Construction Documents
09 Construction Management
10 Observation/Inspection
11 Fabrication
12 Distribution
13 Construction
14 Maintenance

TYPE OF SELECTION PROCESS SS

01 Lump Sum, Competitive
02 Selected Bidders
03 Lump Sum, Negotiated
04 Unit Price, Competitive Bid
05 Unit Price, Lump Sum
06 Cost Plus Fixed Fee
07 Mandatory Low Bid

K. ALLEGATIONS

TYPE OF SUIT/CLAIM/INTENT TO SUE AT

01 Single
02 Multiple, Primary Party Named
03 Multiple, Secondary/Many Parties Named
04 Counter
05 Counter & Multiple

STATUS OF CHARGES AC

01 Notice Of Problem
02 Investigation
03 Informal Claim
04 Claim
05 Negotiation
06 Litigation, In Suit
07 In Trial
08 Settlement
09 In Arbitration
10 Arbitration/Decision
11 Civil Suit Verdict
12 Criminal Verdict
13 State Board Review
14 Appeal Civil Suit Verdict
15 Appeal Criminal Verdict
16 In Mediation
17 Mediation/Decision

AMOUNT PLAINTIFF SUED FOR AS
AMOUNT OF SETTLEMENT AD

0001-0999 (1-999) Dollars
1001-1999 (1-999) Thousand Dollars
2001-2999 (1-999) Million Dollars
3001-3999 (1-999) Billion Dollars

ACTIVITY CAUSING ERROR AA

01 Bidding
02 Planning, Service
03 Design
04 Specifications
05 Field Order/No Cost Change
06 Change Order
07 Fabrication
08 Transportation
09 Construction
10 Inspection/Observation
11 Repair
12 Occupancy
13 Maintenance
14 Testing
15 Nonpayment
16 Installation (Equipment, Etc.)
17 Survey (Land)
18 Demolition

REASON FOR FAILURE AR

01 Poor Assumptions
02 Survey Error
03 Design Error
04 Design Omission
05 Practice Error
06 Improper Specifications
07 Mismanagement/Rush
08 Poor Scheduling
09 Drafting/Copy Error
10 Communications Error
11 Poor Quality Fabrication
12 Poor Quality Material
13 Poor Quality Construction
14 Poor Quality Workmanship
15 Poor Observation/Inspection
16 Poor Maintenance
17 Improper Codes/Standards
18 Negligent Practice
19 Criminal Negligence
20 Intentional Conduct
21 Natural Causes
22 Normal Aging Of Materials
23 Misuse Of Area
24 Vandalism

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Thesis
M8384 Morro
c.1 Constructability improvement.